The Chemical Safety Mechanism

University of Wisconsin-Madison
Office of Chemical Safety

Lessons Learned: A Pressurized Bottle Explosion

When incidents involving injury or property damage occur on campus the Environment, Health & Safety Department (EH&S) takes a look at these to determine the cause and ways of preventing similar incidents from happening again. Even near-miss events are looked at when we become aware of them (see our article *"Under-Reporting of Incidents – An Opportunity Missed"* in our August 2012 issue: http://www.ehs.wisc.edu/documents/chem-IncidentUnderreporting.pdf). Here we will describe an event that occurred a few years back. While details of the event were sent to departments on campus the story may not have had the distribution it deserved since it pre-dated our newsletter.

Glass bottles containing reagents have the potential to explode if they become pressurized due to decomposition or due to reactions with air or water. Indeed, explosions of pressurized glass containers have been reported on other campuses and have been known to cause injuries from flying glass shards. Most of these were cause by inappropriate or accidental mixing of chemicals. The results of this were the generation of gases that pressurized the container once the bottle was capped.

On our campus a reagent bottle containing trichlorosilane (Cl_3SiH), a toxic and highly flammable liquid, burst in the hands of a researcher who was trying to transfer the reagent bottle from a malfunctioning refrigerator to an operational one. The explosion was likely caused by the reaction of the reagent with moisture in the atmosphere resulting in the formation of gaseous hydrogen chloride which pressurized the bottle. The SDS specifically states that trichlorosilane reacts violently with water. The storage section of the SDS indicates that the material should be stored under an inert atmosphere and that any containers which are opened must be carefully resealed and kept upright to prevent leakage.   It also explicitly asserts that over time, pressure may increase causing containers to burst. The warming of the faulty refrigerator may have also contributed to an increase in the pressure within the bottle. Luckily, the incident did not result in any fire and the researcher was unhurt except minor respiratory discomfort due to the hydrochloric acid liberated when the bottle burst.

Trichlorosilane Physical Properties

CAS #: 10025-78-2
Molar Mass: 135.45 g/mol
Density: 1.342 g/cm^3
Solubility in water: Hydrolysis
Boiling Point: 31.8 °C (89 °F)
Vapor Pressure: 493 mmHg at 20 °C (68 °F)
Flash Point: -27 °C (-16.6 °F)
Explosive Range: 1.2% – 90% by Volume
OHSA PEL: 5 ppm   IDLH: 50 ppm (based on HCl)

Positive Actions

A number of positive actions, both before and during the incident, were taken by the research staff.

- The researcher performing the transfer was wearing personal protective equipment (gloves, eye protection, organic vapor respirator), though this could have been improved upon (see below)
- The researcher was accompanied by another individual for backup and support
- Immediately after the explosion the exposed researcher was taken to an emergency shower and decontaminated
- 911 was promptly called and the Madison Fire Department responded within minutes
- An inventory of the contents of the refrigerator had been maintained and was readily available.
- To protect the trichlorosilane from moisture during storage the primary bottle had been placed in an outer glass bottle containing a desiccant.

Incident Concerns and Observations

The review of the incident also uncovered a few concerns, some of which contributed to the incident.

- The refrigerator was overfilled – containing about 140 chemicals – and the chemicals were not stored in an appropriate manner such as by hazard class. The containers were also not placed within any secondary spill containment (see **Figure 2**).
- The trichlorosilane had previously been open but not been used for a number of years which greatly increased the risk of explosion. As indicated above the bottle was placed in a secondary container with a dessicant, but it was not known if the dessicant had ever been changed.
- During the transfer of materials between refrigerators only one of the researchers was wearing a flame-resistant lab coat. Also, the respirator used provided protection against organic vapors but did not provide any protection against the HCL vapors.
- The inventory list, while available, did not contain any hazard information (such as toxicity, flammability, reactivity, etc.). This limited the use of the inventory during the emergency situation. In the immediate after effects of the incident it was uncertain what container had exploded. Those on the scene had to rely on chemical knowledge in order to make informed guesses on the possible cause.

Fig. 1: The remains of the trichlorosilane bottle.

Fig. 2: Refrigerator with stored chemicals.

Lessons Learned

From this incident a number of lessons can be learned which are broadly applicable to the campus. Indeed, the conditions in this refrigerator are not atypical for a research laboratory.

- **Minimize inventory in your refrigerator:** Do not store unnecessary chemicals in a refrigerator. Dispose of all unneeded and no longer useable chemicals as they increase clutter and risk. Date all reactive and unstable chemicals and dispose of after the expiration date.
- **Know your inventory:** Having a list of chemicals is not sufficient. During an emergency is not the time to be assessing the hazards of your inventory. You must know what physical and health hazards are posed by a chemical before beginning work with the chemical. There are many means to document the hazards. Maintaining copies (electronic or paper) of Safety Data Sheets is one way, though other ways are available and are often more useful and practical.
- **Choose proper PPE:** By having knowledge of the hazards of your inventory you can make more informed choices on the PPE that will protect you. Contact EH&S if you have any questions on PPE including respiratory protection.
- **Maintain proper storage:** As mentioned above there were no secondary spill containers. Chemicals can be sorted into secondary containers based on such characteristics as reactivity (flammable, water reactive, etc.) or toxicity (see **Figure 3**). This would make finding and moving the chemicals easier – especially if the inventory list includes secondary container locations. In the event of a refrigerator failure those chemicals that pose the greatest risk or are most temperature sensitive can be easily identified and quickly moved. **If you need to refrigerate flammable liquids make sure your refrigerator is rated to handle these.**
- **Properly seal containers:** Do not store moisture sensitive chemicals in a refrigerator unless the reagent/ chemical caps are properly sealed (use Parafilm® or Teflon® tape around the cap, as appropriate). Use appropriate drying agent in desiccators that have a moisture indicator, and always replace the desiccant when it changes color.

Fig. 3: Storage of chemicals in Secondary Containment

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